Technology, 12(4), 245-257, (2009)

TECHNOLOGY

ANALYSIS OF FREQUENCY BAND FACTOR FOR SOUND ERGONOMICS IN THREE DIFFERENT TYPES OF SPECIAL BUILDINGS

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Abstract

This survey aims to evaluate sound ergonomics which is the special part of the ergonomics. For this aim several public sensitive and mass using areas are selected like schools, hospitals and passenger stations. At this research, firstly Questioner pollIs are used in Turkey. Noise levels, which lead to discomfort and loss of communication in the education area, healthcare centers and railway passenger stations were measured evaluated and compared in several Turkish and several countries' public and music schools, healthcare centers and passenger stations. Measurement results which include equivalent sound pressure levels (Leq and Lmax – Lmin include 20 level in 5 minutes from every point) are evaluated as a function of location, frequency and day. Measurements are taken in Lmax – Lmin range, include 20 levels in 20 seconds, these level ranges can change between 30- 100 and 50 – 120 dB. The spectra are prepared between 16 - 8000 Hz. octave bands for Lmax - Lmin, and A-weighting for Leq measurements. Data gathered at various schools over the last 4 years (2005-2009) indicate a trend of increasing noise levels during daytime hours.

Key Words: Sound ergonomics, Ambient noise, Speech to interfere ratio, Schools, Hospitals

1. Introduction

We can explain the sound ergonomics as a special part of ergonomics that the application of scientific information concerning humans to the design of device, systems and environment for human life and work in efficiently. Work systems, health and safety should all embody ergonomics principles if well designed. Also, when designers are talking about sound ergonomic, they must be dealing with standard sound level of equipments and environment. Sound levels are not only dealing about standard sound level of devices but also deal with using duration and time period, distance, using shape, frequency .... etc. Ambient noise sometimes can be indoor, outdoor noise which reach with airborne or structure borne. But other ambient effects are also important for human in place which peoples are affected. Here we have to talk about professional-life of occupational properties. Ambient sound levels have different effect for different occupational fertility, especially at special occupations and dependently special buildings. In special buildings, like schools, hospitals or passenger stations, those have special identities. Sound is also part of the system and needs acoustic appropriate with the identities. Sound pressure level, intensity and frequency band analysis of buildings is important according to using type. Some special buildings have some different narrow band frequencies like low band frequency, high intensity and low sound pressure level are propagated from bogies, high frequency, high intensity and high SPL but short time period can be propagated between railroad-track and wheels (especially at acceleration and deceleration period), middle band frequency (between 500 – 2000 Hz.) and high intensity and high sound pressure levels at crowded public areas. In this study, some school, hospitals and stations have been taken as an example of special buildings and frequency analysis were done and noise criteria for interior are proposed. When the test result compared against the criteria, serious problems were found at 500 – 1000 Hz. (human sound interval) frequencies.

2. Sound Effect On Special Buildings

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Speech transmission index (STI) is an important objective parameter concerning speech intelligibility for sound transmission channels. Sound ergonomics works are getting important in the time especially for the"Special buildings" which are sensitive to sound characteristics. We can divide the special building into 4 groups [Koçyiğit, 2005] according to behaviour and effectiveness against the sound. One of the groups is [AG[1]1] which is shown that "claver buildings" which main function is directly related with sound. [AG2]; Main function is not related with sound but sound is used as warning and orientation. [AG3]; sound is considered as an ambient noise. [AG4]; these areas are high sensitive for sound. There must be sound level control with special techniques. Frequency bans analysis for noise control is very important in these types of buildings. In this article buildings were also divided in 5 groups for vibration.

Special Buildings firstly can divide into two groups. First group include AG1 and AG2 which sound is used but need control and can name SAA[2]. Second group include AG3 and AG4 which sound is unacceptable and can named SUA. Concert Halls, show rooms, religious buildings are in the first group of SAA-AG1. Here frequency band analysis is very important. SAA-AG2 included Shopping malls, mass-transit systems stations. Here warning and sound orientation systems are vital. SUA-AG3 included hospitals, schools etc. social sensitive areas. Most sensitive areas about sound control are telecommunication studios, Audiology rooms and high technological areas. Also "clever buildings" are one part of the "special buildings" and here AG4 is needed. Because of architectural and interior design are directly effect from sound source and frequency bands analysis for sound control.

Application of room acoustic principle to the special buildings there can be seen that sound propagation directly related with shape and volume of room. Additionally, generally, these types of special buildings have big area. They have several corridors, entrance to open different characteristic area and so on. These types of characteristic shapes create difficulties to application and calculate the principle of room acoustics. Especially for the absorption and insulation solutions which depending on noise control with the frequency band analysis, these types of problems are more effected.

One of the acoustical problems is the "acoustical image" in these types of big and sensitive buildings, which the sound have been reflected from the walls, ceiling and floor. There are several reasons for these problems; a) firstly, generally, special buildings which service to the mass of people in the city, usage materials must be hard and durable, and generally durable and hard materials are reflective if you don't use some relief. b) They are generally big areas which have some corridors, open spaces and several places, which have conjunction between them. c) There are several different geometry which effect the control and calculation of room acoustic. d) Different frequencies of sounds which coming with fluctuating effect from other end of corridors. All these problems are affirmative and non-affirmative affect of the control of sound in the special buildings.

There are several types of special buildings like airports, seaports, metro stations, hospitals, schools, industrial areas, shopping malls etc. Schools, hospitals and Metro Stations are the most usage areas in the city scale. For this reason these three buildings types have been selected for case study of sound ergonomics with frequency band analysis. In spite of, all Metro and ANKARAY Stations' areas have been tested and measured the sound levels in daytime and mid night, only the "Kizilay Station" different areas' noise levels have been evaluated, several public and music schools and also several hospitals have being tested but only one of them is used at this paper. All other species are individually evaluated in separate articles.

Conclusions are compared with national and international noise limits standards, we found that there are only the standards about platform level and entrance levels. These limits include mechanical equipments noise levels and only the limits dependent on dBA. But according to previous paragraph, especially in mezzanine level noise control, sound limits must search according to frequency band analysis.

3. Sound Ergonomics Evaluation On Case Studies

Background noise can be coming from several types of roots. 1. External noise (noise that is generated from outside of the buildings; such as airplane traffic, local construction, etc.), like traffic noise, industrial noise or maintenance and restoration noise, playgrounds, construction vehicles. 2. Internal noise (noise that originates

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[1] AG: Acoustic Group

[2] SAA: Sound Acceptable Areas
SUA: Sound Unacceptable Areas

in the building, but outside the room), of the building; like neighboring rooms, corridors. Noise can come from spaces adjacent to the classroom such as the gym, cafeteria, etc 3. Room noises (noise that is generated within the room), of music room like room lighting, overhead fans, and even the air conditioning and heating units within the room. For example at schools, a great deal of noise can also be generated within the classroom by children themselves and objects and furnishing present in the room. Here the loudness is important. A-weighted background noise is often used in many studies and is defined as sound pressure level measured with conventional frequency weighting that roughly approximates how the human ear hears different frequency components of sound at typical listening levels for speech. The A-weighting attenuates the low frequency content of a sound. (ANSI S 12.60-2002) Background noise in a music room affects the student's ability to perceive music by masking the acoustic and listening cues that are available in the teacher's spoken message. In general, the spectral energy of consonants is less intense than notes energy. Consequently, background noise in the music room predominately reduces notes, music, vowel, consonant perception. Unfortunately, even minimal decreases in these perceptions can significantly influence music perception because the vast majority of a listener's ability to understand notes is the result of consultant energy. (Crandell & Smaldino 2000) [4]

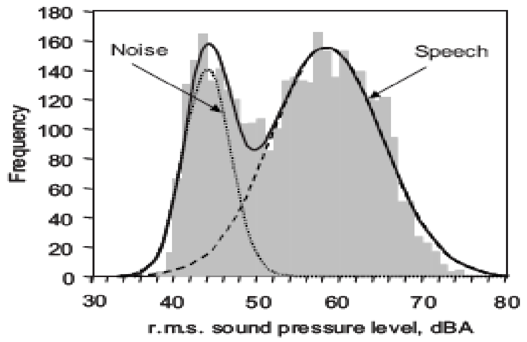


Figure 1. Example frequency distribution of r.m.s. sound pressure level of the recorded 200 ms segments and the fitting of two normal distributions to the data. The left part of the distributions to the distribution includes the predominantly noise segments (mean 43,6 dB A, s.d. 2,8) and the right part the predominantly speech segments (mean 58 dBA, s.d. 6,7). Summation of both normal distributions is shown by the solid line and is seen to approximate the measured data.[5]

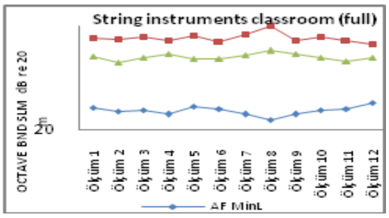
3.1 Case Studies From Schools

According to second part's classification schools are cain SUA-AG3 namely, especially ambient sound is undesirable factor, which is only some of days or times using and need control. Sound ergonomics in schools needs correlation between different discipliner studies. These are education specialists, musicians, architects, city planners, mechanical and electrical engineers.. etc. Explaining and understanding capacity directly related with S/N ratio in classrooms. Namely, sound source can be understandable from some distance if there is no masking effect between sound source and receiver, but if several indoor or outdoor sound confuse to these source understandability ratio can be reduce because of the induce. General this condition occurs because of the students whistles between teacher and receiver student. Namely, if student is sitting in the frond or near the teacher he can easily understand her, but if he is far corner from teacher this will be difficult.

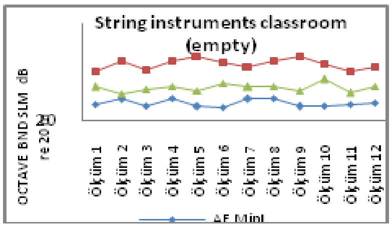
Survey shows that, there are several conditions for reach good acoustics in classroom, especially in music educated schools, identified four reasons for an acoustically sound classroom. For avoiding from problems all disciplines have to work together like avoiding from HVAC noise (mech. engineers), electrical system and loudspeaker noise, (elect. eng.s), outdoor noise (city planners), indoor noise propagations, (architects) and student control (teachers) …etc. Some other reason can be added to these. Some of them are; 1) understanding of children with normal hearing can be seriously affected by a combination of excessive background noise and reverberation. 2) Hearing-impaired (especially using cochlear implant) children are always at a disadvantage compared with normal hearing, but the difference can be minimized by acoustical controls, 3) comprehension between levels for multi syllable and unfamiliar words can be expected to be worse than indicated by monosyllabic testing. 4) Decrease in intelligibility with distance from teacher can be minimized by acoustical treatment and shaping of space. 5) Distinguishing of notes, instruments and human sound at the music. 6) Interfere sound is more effected at the music room then the public lecture rooms. Because frequency of music ranges is wider than talking, depend on vowel and voiceless-consonant. Voiceless-consonants are high frequency letter.[3]

3.1.1 Case Study From M.O. Tounoglu Primary School And H.U. Music School

As an example of MS, HU Conservatory was researched and its sound levels were measured and also other MS, music classrooms and public classrooms were researched and compared. At the measurements, it was seen that transmission loss was very insufficient and ambient noise which is especially outdoor sound gain is too much. FIG. 2and 3 are showing the differences of sound level meter at different MR. Also, according to approximate calculation for a typical classroom, RT is measured between 0.5 – 5.5 sn.(TABLE 6) These results not only un-acceptable for MC, but also for public classroom, regarding the sound pressure level for classroom.

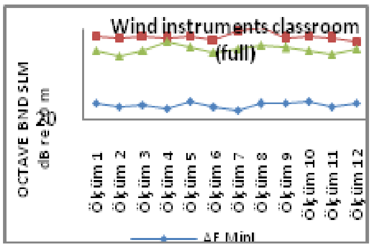


String instruments occupied rooms.

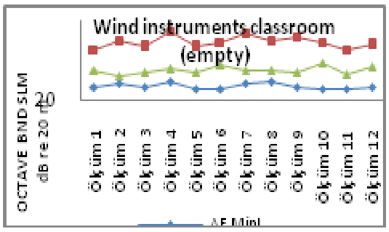


String instruments un-occupied rooms

Fig. 2A: String Instrument rooms



Wind instruments occupied rooms.



Wind instruments un-occupied rooms

Fig. 2B: Wind instrumrnt rooms

Figure 2. Differences of sound level meter at different MR

These figures explain us that outdoor sound is much more effective than other schools. If all music rooms are adjacent, this problem is getting higher. Another effective condition is different types of instruments' classrooms and they must be in different zones. Here the instruments' intensity and frequencies are affecting the problems.

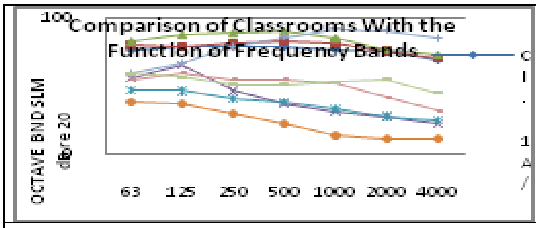
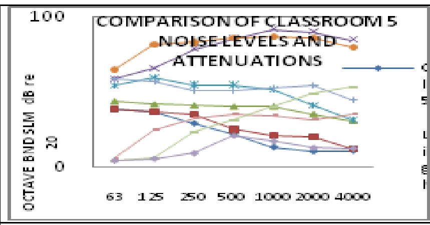
	
Comp. of the classrooms with the function of frequency bands.	Comp.of the classrooms noise levels and attenuation

Figure 3. Comp. different schools' classrooms and attenuations with the function of frequency bands.

3.2 Case Studies From Hospitals

As also mention at part 2 , hospitals can be put in the group of special building and can be accepted at both SAA and SUA AG groups which can be dividing into 4 groups. Namely, Hospitals anonsment systems are very important like passenger stations, but need more control because of the patients and more sensitive for doctor-patient-nurse communication and effect to the patient lies.

Hospitals are not the first things that spring to mind when considering problems with noise and acoustics. Several business area and occupation can accept several different levels of ambient noise and sound. Doctors and nurses are hospital' staffs who deals with patients. So, ambient sound ergonomic s is very important for their healthy and social relation which means life quality. For improving the life quality for these people there are some important subjects. The most common are:

1. Healthy of staffs

2. Speech privacy
3. Social relation and communication between staff to staff and staff to patients.
4. Mechanical services noise within the hospital e.g. lifts, generators, etc.
5. Environmental noise (i.e. complaints from nearby residents) from areas such as laundries, boiler houses, incinerators, etc. Here we have been dealing with;

3.2.1 Healthy Of Staffs

Healthy of staffs is one of the most important reasons for sound ergonomics. At 2000 Hacettepe University academicians had been researched between dental staff and students about the effect of Laboratory Noise on hearing thresholds. Here be seen that in 3 years peoples have been seriously effect from ambient noise. [6]

Table 1. Before and after the ambient noise effect on workers (dentists) between 125 – 18 000 Hz. And average hearing Indus and deviations.

Frequencies (Hz)	Hearing Indus at the beginning of measurement (dB)	Hearing Indus after 3 years (dB)
125	10.7± 4.8	10.8± 7.1
250	8.7± 5.2	9,2± 6,0
500	5,9±4,9	5,8± 5,4
1000	5,7± 4,5	4,4 ±4,1
2000	4,9± 5,3	4,2± 4,9
4000	4,9 ±6,6	5,1 ± 7,5
6000	8,7± 8,8	12,3± 9,1
8000	8,9± 7,3	7,1± 8,2
10000	8,3± 8,6	9,3± 9,6
12000	12,1± 5,4	16,4 ±16,2
14000	12,6 ±17,1	13,7 ±18,1
16000	17,6 ±19,9	15,6± 20,4
18000	36,9 ±17,4	34,2 ±17,0

3.2.2 Speech Privacy

Speech privacy is, in fact a quantifiable feature of a room or area. It is based upon the level of speech versus the level of background noise. The higher level of background noise compared with the level of speech, the greater will be the masking of the speech and hence the privacy. A simple example would be to compare having a conversation in a noisy pub where speech from the adjacent table would be unintelligible, if not completely inaudible, with a conversation in a doctor’s waiting room where even whispered conversation can be clearly heard all round.

In hospitals, a quiet waiting room is not really a problem, as conversation is unlikely to have a specific privacy requirement. It is important, however, if the adjacent consulting room is not adequately insulated to a degree which recognizes the quiet background conditions of the adjacent waiting room, or other consulting rooms. Often the designers will be charged with ensuring low levels of background noise without adequate consideration of consequent speech privacy problems.

As an alternative approach to improved sound insulation of such areas requiring speech privacy, we can consider ensuring an adequate level of background noise. It is, of course, odd that an acoustic consultant should be advocating higher noise levels but, where it is done carefully, it can be a highly effective technique. Some open-plan offices, for instance, actually go as far as generating noise over a sound system which is not really noticeable but makes speech from an adjacent desk an unintelligible murmur.

3.2.3 Mechanical Services

Internal noise, other than that generated by the general hustle and bustle of hospital life is often dominated by mechanical services noise, especially in modern, light-weight buildings where noise and vibration can be transmitted over quite large distances. When looking to the questionnaire reply there can but seen that many of hospital staffs are patient from ventilation systems, generator and other mechanical system noises.

Initially it was tempting to assume that the plant room, which housed the lift power packs, was inadequately insulated against airborne noise. In fact, we can say that two other paths were far more important and lent themselves to cheaper solutions than conventional sound insulation.

1. Airborne noise, i.e. straight forward transmission of airborne sound from the plant room to the nearest bedroom.
2. Structure borne noise in the walls. This is where the power packs body and pipe work is hard-fixed to the floor and walls and sets them vibrating. The vibration can travel over large distances and is radiated off walls as airborne sound.
3. Structure-borne and airborne noise in the pipe work. The pipes were rigidly connected to the power pack, were of lightweight material, and were rigidly fixed to the floors, walls, structural steel work, etc.

3.2.4 Environmental Noise

Noise created by the hospital which can disturb neighbors can take many forms but people are often quite tolerant of general activity noise. It is the more industrial-type noise which tends to cause the problems, such as laundries, incinerators, generators, etc.

We were asked to examine a severe problem with eight laundry fan discharges, which were responsible for fan noise of 75 dB (A) in the back gardens of nearby houses. Background noise was 46 dB (A), an exceeding of some 29 dB (A). This severe noise problem had to be tackled without imposing pressure drops on the fans and was done using very large straight-through silencers.

An entirely different kind of problem was experienced with a noisy incinerator. We built a very full and detailed computer model of the incinerator, including all its significant noise sources. This allowed us to "install" noise control in the model and predict the performance. The most severe problem was from the main induced draught fan which was not as loud as the above laundry fans but equally disturbing to residents due to a very clear and unstable tone. The fan was supplied with an off-the-shelf silencer which was wholly inadequate and, due to the pressure drop it imposed, it was instrumental in the creation of the tones as the fans load went up and down. The solution was to fit a negligible-pressure silencer which was large enough to be effective on the tones.

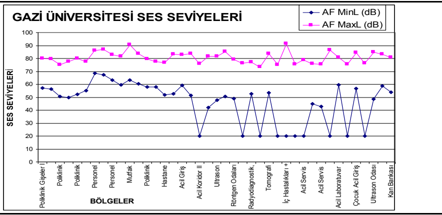
Entrance and platform level are only the short waiting areas for reach the station or getting on the train. Because of the safety, any other activity can't be acceptable. Consequently, multifarious noise source don't be seen. Generally same types of equipments are used at these areas and noises are generally same frequencies band. Also noise levels are more than acceptable level in mezzanine level and too many people are in effect. This is the reason for noise problem in mezzanine levels is vital, and need control and solution.

3.2 5 Case Studies From Hacettepe, Safranbolu And Zku Hospitals

At this series of research there have been several tests in different 5 hospitals which some of them are university research hospitals and some of them are national hospitals. Additionally, 200 doctor questionnaires and 200 nurse questionnaires for every university hospital have been replied this questionnaire. Also all these universities' floor plans surveyed and sound analysis have been analyzing with 10 frequency bands. Research is going on and at this paper on of the hospital, Safranbolu National Hospital, Hacettepe and ZKU University hospitals' researches were overviewed, is used for the example of research. Firstly we saw that, bigness of area is not directly important for ambient noise. All types of healthcare centres show similar behaviour to noise. Using materials, crowdies, relation of areas, activity-ratio, location of area and education level of patients ... etc are more important than bigness. Also, it has been seem that zone and subject of patient department ambient sound frequency are also different with the intensity of sound. Safranbolu is the most crowded and big part of Karabük City. Safranbolu hospital is not only accepting the Safranbolu patients but also accept the neighbour villages' patients also. Because of this character al day time and week especially entrance part and polyclinics are so crowded.

Over the 5 years, we have obtained sound pressure level measurements at five different locations in Hacettepe, Gazi Univ., ZKU Hospitals. These are the Pediatric Units, (the Children's Medical Services Center, and Phlebotomy), outpatiens (inclusing different departments), emergency units(children and adults), hospital entrances and waiting rooms (including corridors, nurses rooms, doctor rooms etc.), patient bedrooms. At each unit we used a consistent protocol for measurements. We first measured one-minute L_{eq} at many locations on the unit, always including patient rooms, hallways, and nurses stations. We simultaneously obtained octave-band sound pressure levels at every location. Subsequently, measurements at a minimum of three places per unit—a patient room, a nurses station, and an examination room or empty patient room. In every case we requested that patients, staff, and visitors continue with their normal activity. All measurements were obtained B&K 2260 SLM equipment. . Results were downloaded to a PC for analysis. Measurements in hallways and patient rooms were made near the room center at a height of roughly 4.5 ft. Some of the halls and some of the rooms had acoustical tile ceilings but no other acoustical treatment. Other locations had no acoustical treatment whatsoever. Thus, we found all of the facilities to be quite reverberant.

Figures 4 show the 1 min A-weighted L_{eq} as a function of location. In each case, the figure shows the L_{max}, L_{eq}, and L_{min} obtained using the slow averaging setting of the meter. In general, there is more variation between rooms on a unit than between hall measurements. This is almost certainly a reflection of the variations in activity in different patient rooms with higher levels corresponding to rooms with multiple visitors or louder playing of the TV.



Fif 4a Gazi Univ.

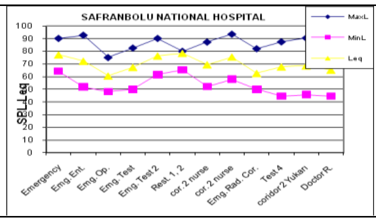


Fig 4b. Safranbolu Nat. Hosp.

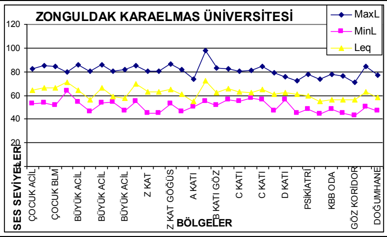


Fig. 4c ZKU Univ.

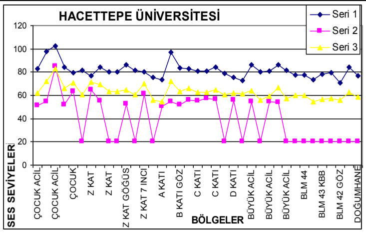


Fig. 4d Hacettepe Univ.

Figure 4. 1 min A-weighted L_{eq} as a function of location

Figures 4 show different hospitals' different zones' sound levels. These are three items of interest. First, not one published result shows a hospital which complies with the WHO guidelines for noise in hospitals. Most of the data, particularly that which is recent, shows sound levels 20–40 dB(A) higher. This certainly raises the question of what significance the guidelines have.

Second, the figures show that there is a clear differences between differen types of hospitals. If the hospital is in the center of the city like Hacettepe University and Gazi University and wellknown generally wery crowded. Crowded hospitals is means noisy places. Againstly if the hospital is far from city center crowded is less effective.The (logarithmic) average A-weighted L_{eq} in hospitals have risen from silent zones 50 dB(A) to noisy zones 80 dB(A) today during daytime hours.

Third, Figs. 4A, 4B show remarkably little variation given that the results are for widely different sorts of hospitals and medical units. Regardless of the reasons for this relative consistency, it suggests that the problem of hospital noise is universal, and that noise control techniques might also be expected to be applicable broadly. The bulk of the work on hospital noise has centered on emergency unit, overall patient room and patient bed room These units do tend to show higher L_{eq} on average than other units included in measurement data, but not dramatically so.

The next sections of this article present new data on noise levels at a particular hospital—Hacettepe, Gazi Univ Hospital in Ankara., ZKU Hospital in Zonguldak. Hacettepe, Gazi Univ., ZKU Hospital are a large research medical facility which services a very broad community.

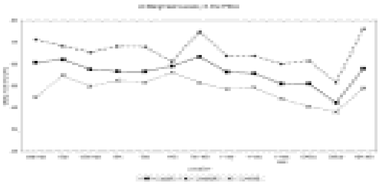


Fig. 5a

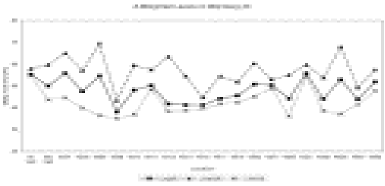


Fig. 5b

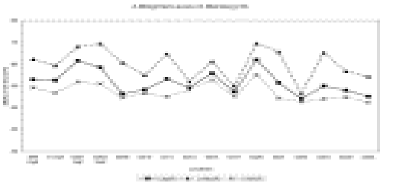


Fig 5c

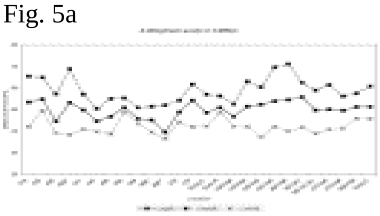


Fig 5d

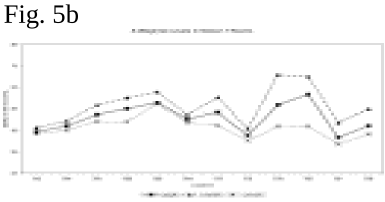


Fig 5e

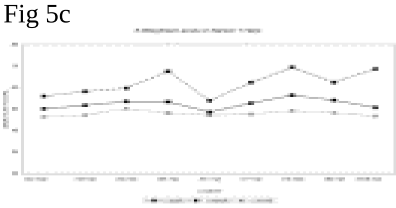


Fig 5f

Figure 5. John Hpkins Univ. Uniform set of sound levels throughout the PICU, which is somewhat surprising given its L-shaped geometry.

The office measurements listed on this figure are two measurements at the office of Nurse Manager Claire Beers. Her office is at the extreme end of the unit. The higher sound level corresponds to the door open, and the lower value to the door closed. All rooms on the unit were occupied. Nurses stations are distributed throughout the larger patient rooms in addition to a main nurses station in the corridor.

Figures 5A,5B,5C show Weinberg results. From these we see that the new building is not particularly quieter than the older buildings. This is surprising given that noise was an issue considered during Weinberg design and construction. Indeed, the construction design called for NC-35 for the new, unoccupied building. Weinberg 4C is significantly quieter than 5C due to the acoustical tile ceiling there. Further, hospital air flow rates have increased significantly in the last 50 years so the older buildings are now driving more air through air ducts than the system was originally designed to handle, while Weinberg was built to handle the current HVAC standards.

Figure 5D shows the 1 min averaged A-weighted L_{eq} measured in CMSC4. CMSC4 is a particularly interesting location because it serves as a living laboratory for the study of hospitals. One of the corridors in this unit is the traditional straight corridor with small indentation places located along the walls which house computers for staff to enter patient data. These tend to be places where physicians congregate, particularly during rounds. The other corridor is nominally parallel to the conventional one, but has been built intentionally with a curvature to it. This prevents line of sight contact down the entire length of the hallway. On the curved corridor, there are small cubicles oriented at 90° to the corridor axis for staff to enter patient data. CMSC4 also has modified their nurses station so that there is a small reception area at the entry to the unit and a larger work area midway into the unit. This contrasts with the conventional approach of congregating the entire nurses station in a single location (except in intensive care units). Figure 8 shows that there is essentially no acoustical advantage gained by the curved corridor. The results for straight corridor rooms (left half of the figure) are about the same as those for the curved corridor (right half of the figure).

Figures 5E,5F show the sound levels on Nelson 7. Here we were able to get measurements in rooms with a greater range of uses, and this is reflected in the variability shown in Fig. 9. The rooms with the highest sound levels were a staff conference room and a patient room with loud conversation. The quietest room was an empty equipment room.

Figures 5 indicate which measurements were in hallways, which in rooms, and which at nurses stations. By considering the nurses stations separately, one sees a pattern emerge—they are generally noisier than the other areas on the unit by 1–2 dB(A). We can also consider the few rooms that were empty and note that they were generally quieter than the occupied rooms, but not always. In particular, when the empty rooms were near nurses stations, they were noisier rather than quieter than the other rooms on the unit. Finally, we had a single set of measurements with an empty room in which we were able to consider the effect of closing the room door. This yielded a noise reduction of 2.2 dB(A) only. Although we did not measure noise transmission through walls from one patient room to another, we did not hear any such sound transmission at any point during our measurements.

3.3 Case Studies From Metro Stations

According to acoustic groups metro stations can be in the part of SUA. In spite of, noise is the undesirable factor but also announcement systems are mostly using in daytime and understandability is vital for staffs and passengers.

3.3.1 Ankara Metro Kizilay, Demetevler And Fatih Passenger StationS

Ankara is the capital of Turkey. It has two-city centre; one of them is the old and other is new cit centre Ulus and Kizilay. Kizilay is new city centre and the most crowded place in city. Kizilay station is shared Metro-ANKARAY and service to both systems. Metro collect the passenger in the North-South line, ANKARAY collect the patrons in the East-West line of city. Lines cross in this station and gathered. Also station is placed in the most crowded centre in Ankara. (Figure 6)
When we look at the new line map of future, continue of lines will be gathering in the Kizilay Station also.

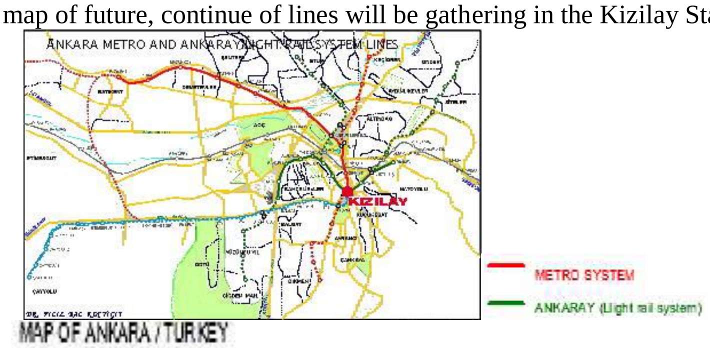


Figure 6. Ankara Metro Line Map

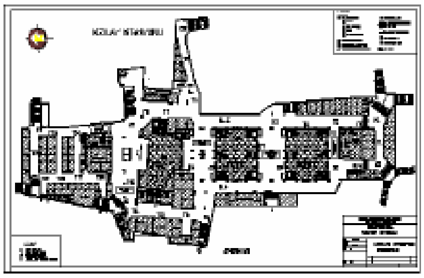


Figure 7. Kizilay Station Mezzanine Level Plan with showing merchant areas.

Figure 8. Kizilay Station Section

As seen in plan (Fig. 7), big part of station are using for merchant area. There are so many sound sources are used in this sections like announcement, music for advertisement. Also, these types of functions are increased the user number. Increased user number is increased the types of sound source frequency. Because of this problem, Kizilay Station selected for case study. For the test study; from the 45 point of mezzanine level noise levels had been measured. 5-time repeat at this point and this test repeated in 7-time period in daytime and midnight. All measured noted in 9-frequency band (31.5 Hz., 63 Hz., 125 Hz., 250 Hz., 500 Hz., 1000 Hz., 2000 Hz., 4000 Hz., 8000 Hz.) but 31.5 Hz., 63 Hz. and 8000 Hz. frequency band analysis did not effected so this bands did not show in figures.

4. Application Of Room Acoustic Theory To Schools, Hospitals And Metro Stations

At the research NC Curves had been selected for the evaluation of test results. For easily understanding the results of test are acceptable or not. Firstly we can adapt the WHO, EPA, limits to the NR and NC curves, so with the help of table of WHO, EPA and ISO standards selected the acceptable, comfort or problem of noise levels and shown in the figure as;

Table 2. Acoustical Requirements for Closed Areas

Use of Space	Requirements for Noise Control			Requirements for Interior Design		
				Reverberation Time (s.)		
	Desired Background (dB)	Speech Privacy	Maximum Sound	Reverb. Time (s.)	Ac. Groups	Sound Amp.
Office						
Open area	NC 35-45 or (30-40)	Not important	Footfalls	0,8-1 s.	3	Yes
Closed or special offices	NC 25-35	Conversation area	Footfalls	0,8-1 s.	3	Yes
Noisy bldg.	NC 25-35	Not important	Dancing hall	0,8-1 s.	3	
High security	NC 25-35	Security is important	Footfalls	0,8-1 s.	4	
Library						
Reading	NC 25-35	Conversation area	Footfalls	0,8-1 s.	3-4	
Reference	NC 25-35	Conversation area	Footfalls	0,8-1 s.	3-4	
Other						
Classroom	NC 25-35	Conversation area	Footfalls	-	2-3	
Museum	NC 25-35	Not important	Footfalls	0,8-1 s.	3-4	
Meditation	NC 35-45	Special area	Footfalls	0,7 s.	4	

[Kocyigit, Filiz BAL, 2003]

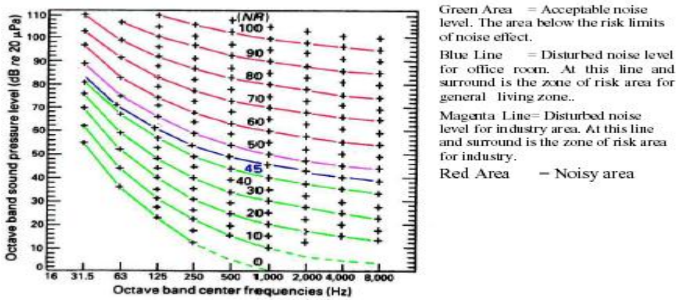


Figure 9. Noise Rates Curves' relation between limits of acceptable noise according to several organizations

Preferred Noise Criterion curves (PNC) are often used to judge the acceptability of ventilation and other background broad band noise. Noise Criterion - NC - curves are generally preferred over PNC curves, because the PNC criteria at lower frequencies are more stringent than that of the NC curves.

Table 3. PNC-type criteria provide no protection for low frequency sound exposure, and further, tend to rely on the public's increasing toleration of background noise and what seems to be decreasing auditory skills.

Maximum Sound Pressure Level (dB)									
PNC	Center frequency (Hz)								
Preferred Noise Criterion	**31.5**	**63.0**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
PNC - 15	58	43	35	28	21	15	10	8	8
PNC - 20	59	46	39	32	26	20	15	13	13
PNC - 25	60	49	43	37	31	25	20	18	18
PNC - 30	61	52	46	41	35	30	25	23	23
PNC - 35	62	55	50	45	40	35	30	28	28
PNC - 40	64	59	54	50	45	40	35	33	33
PNC - 45	67	63	58	54	50	45	41	38	38

PNC - 50	70	66	62	58	54	50	46	43	43
PNC - 55	73	70	66	62	59	55	51	48	48
PNC - 60	76	73	69	66	63	59	56	53	53
PNC - 65	79	76	73	70	67	64	61	58	58

When we test some zones we reached solution Fig.5 and 6, we can see that all frequency band noise levels are not same. Here we can say that between 500Hz.-1000 Hz. Maximum effected noise level frequency band. When we look at the figure 5 and 6 it is shown that dBA level and 250 Hz. and 2000 Hz. level approximately same, but between 500 Hz. 1000 Hz. levels noise levels are reach to the top.

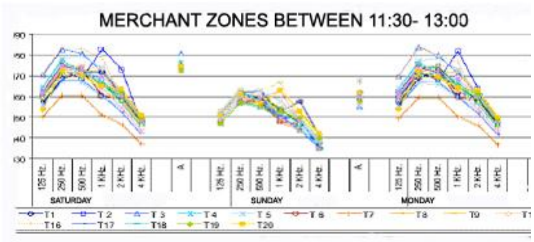
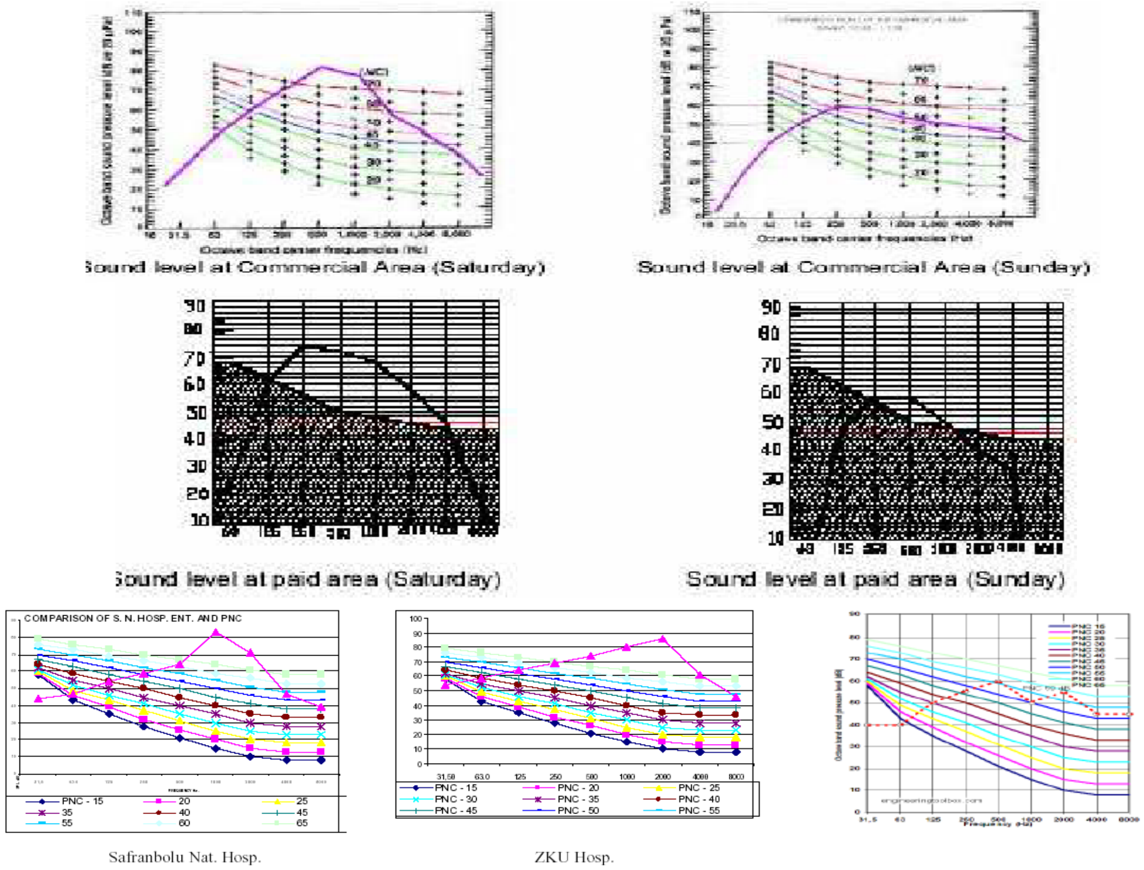


Figure. 10. Entrance Zones' average according to frequency band analysis, at HVAC system off (Between 11:30-3:30)

5. Application Of Room Acoustic Theory To Researched Areas

At the research NC Curves had been selected for the evaluation of test results. For easily understanding the results of test are acceptable or not. Firstly we can adapt the WHO, EPA, limits to the NR and NC curves, so with the help of table of WHO, EPA and ISO standards selected the acceptable, comfort or problem of noise levels and shown in the Table 1) is adapted to the PNC (preferred noise criterion) curves.



PNC 57 and 57 dB average ambient noise

Figure 11. Comparison of Metro Station's some pars and Safranbolu National Hospital's entrance, ZKU hospital's entrance noise levels and PN Criterions Curves

When we test some zones we reached solution Fig. 5 Here we can see that all frequency band noise levels are not same. Here we can say that between 500Hz.-1000 Hz. Maximum effected noise level frequency bands. When we look at the figure is shown that dBA level and 250 Hz. and 2000 Hz. level approximately same, but between500 Hz. 1000 Hz. levels noise levels are reach to the top.

Here can be compare the hospital - hospital and hospitals - Metro Station entrance noise curve for the understanding of differentiate and similarities between different ambient sound zones. And also when we look at the questionnaires; we can found that metro station staffs and passengers reply is "we are used to this noise and generally we are not affected" but in hospital this sound level is seem to very noisy effect.
When looking at the Figure, can see that the Preferred Noise Criterion - PNC - of a noise spectrum likes: 1) 31.5: 40 dB, 62.5 Hz: 40 dB, 125 Hz: 50 dB, 250 Hz: 55 dB, 500 Hz: 60 dB, 45 dB can be estimated to PNC = 57 dB as indicated in the diagram above. Here we can say that ambient noise is 57 dB in example place of hospital is acceptable but at the graphic

6. Conclusion

It is well known that nowadays, because of the population growth and difficulties in urban, our life quality effected from several factors like transportation, education, healthy or wasting time because of crowded and noisy. But, if we want to care our healthy, we cannot neglect the life quality in our working and living areas. Sound ergonomics is one of the important factor in our life for the improving our life quality. Last decade acoustics get own importance in living technology and academicians trying to find new Technologies about this subject. Generally these works are about critical subject and limits but we should not neglect that for ordinary day time using limits are getting dangerous limits, if you use it for a long time period. Here interdisciplinary working getting importance, like medicine, engineering, design, sociology … etc.

We can say that the noise levels are too high in schools, passenger stations and hospitals. Also, the public survey had been made about noise effect to the people in these areas. When the question was "do you effect the noise in station" in the metro stations, the answer was "we used to this noise". [11] This is show that the people are disturb this noise but don't show mass reaction. When we look at the ISO/R 1996: 1974 it says that if the noise level is +5 more than the comfort level there are some personally reactions, if the noise level is +10 more than the comfort level there will be group reactions, if the noise level is +20 more than comfort level there will be mass reactions. When we look at the Kizilay Station we can see that from Fig. 8,9 the noise level is +25 - +35 dB more than the comfort level, but no reaction. I thing the reason is hide behind the answer of "we used to this noise". At the below, there can be seen the graphic of measured noise levels in Kizilay Station which compare with NC45 curve. Here we can say that the area behind the NC45 curve is comfortable area. Upper of NC45 curve is social, physical and psychological risk area for people.

Also, when we look at the hospitals, we can not say that users are not really knows every time what type of noise pollutions are effected them. If they used to this conditions they are not replying their questionnaire real factors. For example, when looking at the children department of medical centre in spite of ventilation systems' noise level too high (this can also understand of from the frequency of ambient noise) staffs are only mutter from patients. But, in other side, perhaps the baby can't sleep with classical music, but with the "white noise" which include home's ordinary have. So, this is effect the way of research and solutions. With the research it can be understand that people are muttering when if the noise is unexpected. But this is not means that high level of ambient noise is not dangerous effect to the hearing induce in the long period.

We have embarked on collaboration with education personnel at selected center to consider technological solutions to communication problems which permit improved speech recognition. In particular, the advantage of stereophonic sound reception has not been exploited in school environments using sound systems so we are working to demonstrate such systems and incorporate their advantages. According to us, there is a great need for the development quite HVAC system such as overhead paging. Such education center items could be tested and marketed on the basis of their ability to perform well while producing less noise. Overall, most people will spend some time in school and many will spend a large amount of time in them. The problem of school noise is clearly under-studied and not well understood. Our goal is to alter this neglected field in meaningful ways.

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